NUCLEAR CAMERA WITH
OPEN AND FLEXIBLE SOFTWARE ARCHITECTURE

This invention relates to nuclear (gamma) camera
imaging systems and, in particular, to nuclear
cameras with software architectures which are easy to
understand and readily adapted to changing needs of
clinicians.

Traditionally, medical image data obtained from
medical imaging systems such as nuclear cameras,
computed tomography scanners, magnetic resonance
imaging systems and ultrasound has been defined by
proprietary image data formats developed by the
various system manufacturers. Such proprietary image
formats mean that the images produced by the
different systems must be viewed or displayed by
proprietary viewing/display applications provided by
each vendor. A user is effectively locked into using
the particular manufacturer's proprietary formats.
Images produced by one imaging system cannot be
readily viewed on another manufacturer's system.
Realizing these limitations, the NEMA trade
organization has organized and defined an image
format which all manufacturers can use, known as the
DICOM (Digital Imaging and COmmunication in Medicine)
standard. The various manufacturers of medical
imaging equipment can provide translators by which
their proprietary formats can be converted into a
common format in which users can exchange and view
images on a variety of different display devices.

Data format standards such as DICOM have not
fully solved the problems of incompatibility and ease
of use, however. First of all, a user of a
particular system must have access to conversion
routines by which a manufacturer's proprietary image

format can be translated into the standard format.
Conversion routines are not always readily available
or universally successful in their operation.
Secondly, the proprietary image data formats are
5   typically inflexible with respect to changes.
Changes are often desirable to enable a clinician to
satisfy new user requirements, or incorporate
innovations into an application, use or operation of
the medical imaging system, or to enable the use of
10   new software technologies that improve the
performance of the medical imaging system. Thus,
proprietary image formats have the effect of limiting
innovation in imaging by clinicians and thwarting
improvements to clinical productivity.
15   Furthermore, while image data standards such as
DICOM enable users to exchange and use images from
the medical imaging systems of different
manufacturers, these standards are only effective
when all manufacturers agree upon the standards and
20   their requirements. The need for common agreement
upon standards means that changes to standards cannot
be made quickly and easily. Proposed changes need to
be discussed, commented upon, and agreed to by the
manufacturers before being implemented for the
25   benefit of end users. Accordingly it is desirable
for a medical imaging system to have a software
architecture which overcomes these obstacles and
readily accommodates advances in efficiencies and
techniques as they are developed by the medical
30   community.
            In accordance with the principles of the present
invention a nuclear camera software architecture is
described which addresses these deficiencies of
proprietary and standard formats. The software
35   architecture of a camera of the present invention

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allows the operation and performance of the camera to be readily modified by users. Modified data can be easily exchanged because of the self-descriptive nature of the software language and the ability to

5   provide readily available format descriptions to all users. In a preferred embodiment the software architecture embraces an open format which is publicly available. In a constructed embodiment of the present invention the software architecture of

10 the nuclear camera uses eXtensible Markup Language (XML) which is an open format that enables changes to the data format to be made by users and other manufacturers alike. The inventive software architecture presents data that is self-describing in

15 that relationships between various pieces of data are captured in the format definition used to store and interpret the data. In a preferred embodiment, both image data and nuclear camera control information, in particular, study protocols, are defined in the open,

20 extensible software architecture, enabling users to exchange not only new image data formats but also new system control procedures.

In the drawings:

FIGURE 1 illustrates in block diagram form a gamma

25 camera constructed in accordance with the principles of the present invention;

FIGURE 2 illustrates the detector of a gamma camera in block diagram form;

FIGURE 3 illustrates a gamma camera protocol

30 setup screen for a gated SPECT study;

FIGURE 4 illustrates the flow of control and image data in a gamma camera constructed in accordance with the principles of the present invention;

35 FIGURE 5 illustrates the organization of patient

data in a constructed embodiment of the present invention; and

FIGURES 6-9 illustrate the directory structure of the software architecture of a preferred

5   embodiment of the present invention.

Referring first to FIGURE 1, a gamma camera constructed in accordance with the principles of the present invention is shown in block diagram form. A software architecture of the present invention may be

10   used with either a single detector gamma camera, or with a dual detector gamma camera such as those shown in U.S. Patents 5,760,402 (Hug. et al.) or 6,150,662 (Hug et al.). The dual detector cameras shown in these patents are commercially available as the Forte

15   ™ and Skylight™ gamma cameras from ADAC Laboratories of Milpitas, California. These camera systems include one or more detectors 10, 12 which sense scintillation events and transfer event data over a high speed serial bus 24a, 24b from each detector to

20   an acquisition control server 14. The acquisition control server 14 bins the event data into images, which are then sent by way of a router 20 to a database host 28 connected to a department Ethernet 26. The database host 28 is the computer on which

25   the acquired images are normally saved. The database host is also the processing and viewing station where 3D reconstruction, re-slicing and presentation of the processed images to the user is performed. The router 20 serves to isolate internal camera data

30   traffic from more varied departmental data traffic. A user interface personal computer 16 is coupled to the acquisition portion of the gamma camera by the router 20 and an Ethernet network 22a, 22b, 22c. The p.c. 16 controls and monitors the image data

35   acquisition and may perform additional image

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processing and display functions using an image display 18. P-scope and energy spectrum data may be displayed to the user on the display 18, enabling the user to position the patient properly in front of the

5   camera, set energy windows correctly, and review acquired data, for instance.

A camera detector is shown in greater detail in FIGURE 2. As is well known in the art, a gamma camera detector is composed of a collimator 32, a

10   scintillation crystal 34, and a lightguide 36. The photons produced by the crystal 34 and guided through the lightguide 36 are received by an array of photomultiplier tubes (PMTs) 38. A scintillation event is usually received over an area covering

15   several PMTs, and the outputs of the tubes are sensed and used to locate the position on the detector at which the radiation event was received. The PMT output signals are amplified by pre-amplifiers 42 and digitally sampled by A/D converters 44. The samples

20   from each PMT are accumulated for the duration of a scintillation event and, since multiple PMTs are involved in the detection of a single event, the accumulated outputs of multiple PMTs are accumulated to acquire the overall energy signal for a particular

25   scintillation event. The detected energy data and location data from each scintillation event is modified by correction circuitry 46, which produces the detector outputs for energy (E) and event location (X,Y). The event data is then binned for

30   image processing.

The p.c. 16 and user interface display 18 allow a user via keyboard and/or pointer control to select or create a predefined set of parameters (or protocols) for direction of a SPECT imaging session

35   or other selected study by the gamma camera system.

FIGURE 3 illustrates a parameter interface screen and
configurable parameters of a nuclear camera system
for data acquisition that are selected and displayed
on a screen by the user. FIGURE 3 illustrates some
5   of the parameters that are configurable by the user
for a desired study. It is appreciated that once
set, the configurable parameters can be saved and
referenced in a computer file for subsequent recall.
The stored parameters or protocol file can then be
10   recalled and utilized for another study, thus
eliminating the need to again enter the parameters
for similar or identical studies. The name of the
parameter file shown in FIGURE 3 is "GATED SPECT" and
is indicated at 300. It is appreciated that the
15   acquisition system, once instructed by the user, will
relay the parameters set by the user to the camera in
order to initialize and begin a particular study.
The initiation is done by selection of processing
command 357. A user interface of this type is thus
20   versatile while at the same time providing a high
degree of automation of the execution of selected
study protocols.

    FIGURE 4 illustrates the flow of control and
image data in a gamma camera constructed in
25   accordance with the principles of the present
invention. Located on the acquisition control server
hardware 14 are a control server 52 and a data server
54. These servers act to access and process data
stored on an xml data storage device 56. The data
30   stored on the device 56 includes patient schedule
data 56a, protocol data 56b, isotope data 56c, and
collimator data 56d. This data is used to operate
and control the gamma camera 82. In a preferred
embodiment this data is stored in xml format as
35   explained more fully below. The control server uses

the data stored on the device 56 and executes programs 52a called "scripts," also stored on the xml data storage device 56, to control the operation of the gamma camera 82. The control and data servers

5   both operate under user control through a graphical user interface (GUI) client application 60 which runs on the user interface p.c. 16.

In operation the user defines a study (exam) by associating a protocol with a particular patient

10   through the GUI client 60. The protocol comes from the data server 54. The GUI client then sends the study to the control server 52. The protocol for the study has a script name attached to it, enabling the control server to identify the script to execute

15   within its interpreter. The script is executed to carry out the protocol, performing calculations as needed, and can obtain certain protocol parameters from the user such as number of azimuths, time per frame, and so forth. The script also prompts the

20   user at various points during the study for further input as needed, such as selection of a point of interest to be tracked by the detectors as they rotate about the patient.

In a constructed embodiment the scripts are

25   written in a scripting language called EASL. EASL was developed by the assignee company of the present invention using readily available tools for writing scripting language such as LEX and YACC. YACC is a UNIX-based tool which enables a programmer to compile

30   the grammatical terms used in EASL to interpret the scripts. The EASL program is an interpreter for the scripts, which in turn use the xml files, and is stored in the control server 52.

The event data produced by the camera detectors

35   Head1 and Head2 in this example is processed as

described above and transferred to a binner 70. The
binner interacts with the control server 52 to format
image data in an xml format. The formatted image
data is then further processed, transferred or stored
5   as described more fully below.

FIGURE 5 illustrates one form of organization of
an xml image file. The image file includes
information about the image such as the
identification 90 of the patient, the nature of the
10   nuclear study 92 which produced the image, the series
94 of the study, and the image information 96. In
the illustration this information is all contained in
an xml image file 100 referred to in this example as
<ADACImage.xml>. The file includes the patient and
15   study information just described, and the image data
shown as 102. The file may contain other pieces of
information 112, 114 which relate to the image and
may also relate to each other. The meanings of these
pieces of information and their relationships are
20   captured in a definitional file called a Document
Type Definition 110 (DTD) file. The image file 100
has a pointer to the DTD file 110 by which a
processor or viewer can access the DTD file and
interpret the information in the image file. The
25   pointer can be to another file or directory running
on the gamma camera as described below. The pointer
can also be the URL of a location where the DTD file
can be found. For example, if the image is being
viewed by a browser, the browser will consult the DTD
30   at the noted URL on-the-fly, and thus be able to
interpret and understand the pieces 112, 114 of
information which are stored in the image file 100.

An example of an <ADACImage.xml> file is shown
in Appendix 1 below. It is seen that the second line
35   of the file contains the pointer·to the DTD file

ADACImage.dtd which defines the relationships of the
data elements in the xml image file. The initial
portion of the file contains information of the type
shown at 90-94, including the equipment and detector
5   used, the reconstruction processing used, patient
information, isotope dose, and so forth. Toward the
end of the file is a block of frame pixel
information.

The initial portion of a DTD file which
10   interprets the <ADACImage.xml> file is shown in
Appendix 2. This <ADACImage.dtd> file is pointed to
in the second line of the <ADACImage.xml> file and
provides instructions to a reader as to the
interpretation of the <ADACImage.xml> file. This
15   particular DTD file begins with information as to the
purpose, creation, and revision history of the DTD
file. This is followed by a definition of the
various elements of the image.xml file. The
<ADACImage.xml> file is written in accordance with
20   the rules set forth in the <ADACImage.dtd> file.

The xml files are seen to be written in easily
understandable grammatical terms. With xml files a
user is able to make changes to the xml file
structure, adding user-desired information to the
25   data already produced by the camera system. The user
is able to make changes to algorithms executed by the
scripts such as study protocols carried out by the
gamma camera. The grammar-based nature of the xml
files makes it easy to add newly defined xml files or
30   to change existing ones, for instance, to create
custom study protocols. Image files can be modified
by a hospital user, for instance to add the
hospital's unique codes and information such as
accession numbers to image data. The DTD file
35   referenced by an image would in that case define the

relation of the accession number to a particular
image and patient. Since xml is an open format the
ability to make these changes is available to all
users. In most instances these changes are evident
5   in the xml files themselves due to the self-
describing nature of the xml and DTD files, with the
format defining how the different elements in the
data relate to each other. The xml-formatted files
can be viewed on a browser or on a text editor which
10   reveals the grammatical text of the files. The xml
files can also be viewed with commercially available
xml viewers such as xmlspy. The relationships of the
elements of the file can be viewed in this way as the
hierarchy of relationships is shown automatically by
15   the viewer. A particular application can thus make
use of all of the relationships defined for the data.

A portion of another example of an xml file,
<protocol.xml>, is shown in Appendix 3. The
<protocol.xml> file has a script name attached to it
20   to enable the gamma camera to carry out a study
protocol called "MIBI." Within a protocol are
various steps, each representing a different
acquisition step, e.g., for a static image, a stress
cardiac study, or a whole body study. In the
25   illustrated <protocol.xml> file the different
characteristics of the study are called "TRAITS,"
which are interpreted and defined by the
"protocol.dtd" file referred to by the <protocol.xml>
file. Typical TRAITS include such characteristics as
30   the detector rotation, the time at each detector
orientation, the frames acquired at each step, and
the isotope dosage used. The defined TRAITS are then
used in the steps of the protocol identified in the
file as <acquisitionstep>.
35   Appendix 4 illustrates an EASL script called

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"tbbase.asl" for conducting a total body nuclear
study. The illustrated script is written in the EASL
scripting language referred to above. The script is
seen to include comment lines which make the script
5   easily understandable to users. The script is also
seen to control the prompts and messages displayed to
the user on the GUI as the study proceeds. In a
gamma camera of the present invention a script is
loaded into the interpreter and is used to run the
10   protocols which control the operation of the camera.

         Examples of the directory hierarchy of the files
stored on the data storage device 56 are shown in
FIGURES 6-9. In these examples the directory
/export/home/atlas/ contains two types of data as
15   shown in FIGURE 6. Software shipped with the gamma
camera by the manufacturer is stored in the etc/
directory. This includes configuration files,
default protocols, default users, default isotopes,
collimators, and so forth. This is primarily data
20   used by the control server 52, the data server 54,
and the binner 70, and comprise a complete set of
files necessary to operate the gamma camera. A data/
directory is also provided for storage of data
created by the user. This includes acquired image
25   data, user defined protocols, schedules of patients,
isotopes, energy window settings, and other files
created or modified by the user.

         FIGURE 7 shows further details of the
manufacturer-supplied directory etc/. The
30   collimators.xml file contains a list of all
collimators supported by the camera. Isotopes.xml
and energywindowsets.xml contain lists of isotopes
and their physical properties and default energy
window settings. Protocols.xml contains a list of
35   standard study protocols. Systems.xml contains a

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list of systems used by the camera, and whether they are clients or servers. Users.xml contains a list of default users for the camera.

5
The directory data/ for user-created data is shown in FIGURE 8. This directory has files corresponding to those of the etc/ directory, but in this case the files are those which have been created by or modified by a user. For instance, a user may take a manufacturer-supplied protocol and modify it

10
for a particular study which the user desires to perform. The modified protocol is stored as a protocols.xml file in the data/ directory and can be called up and executed by the user each time the user wants to conduct that study. The user-created data

15
takes precedence over the manufacturer-supplied data. Any time a client asks for data from the data server 54, the server will first access the data/ directory to see if a user-created file satisfies the request. Only if no user-created file is found will the server

20
look for a file in the etc/ directory.

Both directories are seen to store DTD files corresponding to the xml files, which are used to interpret the definitions in the corresponding xml files. The patient.dtd file, for instance, defines

25
how the patient visit and study information is written out, that is, the format and relationship between the various pieces of information contained in the patients.xml file. Similarly, protocol.dtd defines how the protocol information is written out

30
and interpreted. A DTD file is used to view an xml file when using an xml viewer such as xmlspy, or alternatively a text editor can be used to view the xml file in the form shown in the appendices.

FIGURE 9 illustrates the production and storage

35
of an image.xml file by the camera. The binner 70

writes out the results of a particular study in xml
format when acquisition is completed for a given
acquisition step of a protocol. The image.xml file
is written by the binner in accordance with the rules
5   in the ADACImage.dtd file. This example shows an
image file 015N0000.xml which has been stored under a
particular patient's name, *<patient_name>/*, under the
data/Patients/ directory. Image.xml files are
translated with the help of an "xml2peg" translator
10   program into an image format 015N0000.img and stored
under an x2pout/ directory. This directory is
accessed by the database host 28 in response to an
external user request for the patient's images. When
a particular image has been exported to the database
15   host, the image is then stored under the
SentToDatabase/ directory and a confirmation of the
export is sent as a status update to the data server
54. Thus, images are available in both an xml format
and in an image format which is most efficient for
20   storage, transport or display by the database host.

Appendix 1 - <ADACImage.xml>

```
<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE ADACImage SYSTEM "adacimage.dtd">

<ADACImage>
  <ADACPrivateIOD>
    <ADACAcquisitionIE numberOfXYSets="1" objectDataType="SP"
uniqueObjectKey="01" uniquePatientKey="" corCorrectionFlag=""
scaleFactorOfSets="1.0" isotopeImagingMode="0"
totalAcquisitionTime="60000" uniformityCorrection="">
    </ADACAcquisitionIE>
    <ADACEquipmentIE clientName="cameraclient">
      <ADACDetectorModule fieldOfViewInMM="597.000000"
leadingDetector="head1" calibrationFactor="0.145752"
crystallThickness="0.000000" tubePatternCorection="180"
axisOfRotaionCorrection="0" angleBetweenTheDetectors="180"/>
    </ADACEquipmentIE>
    <ADACReconstructionAndProcessingIE manipulatedImage="N"
curveOrROISetName="" specificCurveName="" reconstructionType=""
associatedParentFile="" associatedNormalCurveFile=""
associatedPathAndFileName="" xDimensionOfAssciatedImage="0"
yDimensionOfAssciatedImage="0" approximateEjectionFraction="0.0"
associatedHistogramCurveFile=""
limitedReconstructionStartSlice="0">
      <FilterModule filterType="" filterOrder="0"
filterCutoffFrequncey="0.0"/>
      <ROIModule roiMode="" roiName="" roiType="" roiColor=""
associatedROI_ID="" roiNumberOfPoints="" centerOfBoundingBox=""
roiBoundingBoxCoords="" xLengthOfBoundingBox=""
yLengthOfBoundingBox="" imageFrameNumberOfROI=""
numberOfCurvesOrROIsInSet=""/>
      <ReorientationModule reorientationType=""
reorientationAzimuth="0" reorientationElevation="0"/>
      <ColorModule trueColorFlag="1" associatedColorMap="0"
customizedColorMap="" lowerLevelGrayShade="0"
upperWindowGrayShade="0"/>
    </ADACReconstructionAndProcessingIE>
    <ADACMiscIE unUsed1="" unUsed2="" unUsed3="" unUsed4=""
dirEntries="" maxTimeValue="" minTimeValue="" vfrStructure=""
rateDifference="" imageOrientation="0" sizeOfSubHeaders=""
binningAlgoVersion="" dataStructureArray=""
adacPatientPosition="other" programSpecifiResult=""
verticalFOVOffsetInMM="0.000000"
horizontalFOVOffsetInMM="0.000000">
    </ADACMiscIE>
    <ADACCorrectionsIE>
      <CORCorrectionModule>
      </CORCorrectionModule>
      <ImageOffsetCorrectionModule>
      </ImageOffsetCorrectionModule>
    </ADACCorrectionsIE>
  </ADACPrivateIOD>
  <NMImageIOD>
    <PatientIE>
```

```
                <PatientModule patientsID="1122" ethnicGroup=""
          patientsSex="O" patientsName="First_da26, Gary"
          patientComments="" patientsBirthDate="" patientsBirthTime="">
                </PatientModule>
  5           </PatientIE>
              <StudyIE>
                <GeneralStudyModule studyID="015700" studyDate="20010507"
          studyTime="13:25:51" accessionNumber="::200157D0J05"
          studyInstanceID="" studyDescription="BASE-static"
 10       referringPhysiciansName="">
                    <ProcedureCodeSequence>
                      <CodeSequenceMacro>
                        <BasicCodedEntry/>
                        <EnhancedEncodingMode/>
 15                   </CodeSequenceMacro>
                    </ProcedureCodeSequence>
                </GeneralStudyModule>
                <PatientStudyModule occupation="" patientsAge="0"
          patientsSize="0" patientsWeight="0" additionalPatientsHistory=""
 20       admittingDiagnosesDescription=""/>
              </StudyIE>
              <SeriesIE>
                <GeneralSeriesModule modality="NM" seriesDate="20010507"
          seriesTime="13:25:51" protocolName="" seriesNumber=""
 25       operatorsName="" patientPosition="OTHER" seriesDescription=""
          seriesInstanceUID="" performedProcedureStepID=""
          performingPhysiciansName="" largestPixelValueInSeries="2.000000"
          smallestPixelValueInSeries="0.000000"
          performedProcedureStepStartDate=""
 30       performedProcedureStepStartTime=""
          performedProcedureStepDescription="">
                </GeneralSeriesModule>
              </SeriesIE>
              <FrameOfReferenceIE>
 35             <FrameOfReferenceModule frameOfReferenceUID=""
          positionReferenceIndicator=""/>
              </FrameOfReferenceIE>
              <EquipmentIE>
                <GeneralEquipmentModule stationName="Atlantis"
 40       manufacturer="ADAC Laboratories" institutionName="ADAC01"
          pixelPaddingValue="" spatialResolution="1.0"
          deviceSerialNumber="atlas-97001" dateOfLastCalibration=""
          timeOfLastCalibration="" manufacturersModelName=""
          institutionalDepartmentName="">
 45               <InstitutionAddress>
                    <Address zip="" city="" state="" country=""
          streetName="" numberInTheStreet=""/>
                  </InstitutionAddress>
                  <SoftwareVersions binnerVersion="8.0b"
 50       dataServerVersion="" controlServerVersion=""
          graphicUserInterfaceVersion=""/>
                </GeneralEquipmentModule>
              </EquipmentIE>
              <ImageIE>
 55             <GeneralImageModule imageDate="" imageTime=""
          imageType="STATIC" imageComments="" instanceNumber=""
          acquisitionDate="20010507" acquisitionTime="13:25:51"
```

```
      acquisitionNumber="" patientOrientation=""
      imagesInAcquisition="" qualityControlImage="N"
      derivationDescription="" lossyImageCompressionRatio="">
          </GeneralImageModule>
 5        <NMImagePixelModule highBit="11" bitsStored="12"
      pixelSpacing="" bitsAllocated="16" samplesPerPixel="1"
      photometricInterpretation="PALETTECOLOR"/>
          <MultiFrameModule numberOfFrames="2">
            <FrameIncrementPointer>
10            <DetectorVector> 1, 2</DetectorVector>
            </FrameIncrementPointer>
          </MultiFrameModule>
          <NMMultiFrameModule numberOfPhases="NO_VALUE_SET"
      numberOfSlices="" numberOfDetectors="2"
15    numberOfRotations="NO_VALUE_SET"
      numberOfTimeSlots="NO_VALUE_SET"
      numberOfRRIntervals="NO_VALUE_SET"
      numberOfEnergyWindows="NO_VALUE_SET">
            <FrameIncrementPointer>
20            <DetectorVector> 1, 2</DetectorVector>
            </FrameIncrementPointer>
          </NMMultiFrameModule>
          <NMImageModule imageID="" countRate="" imageType="STATIC"
      tableHeight="0.000000" tableTraverse=""
25    countsAccumulated="766.000000" processingFunction=""
      actualFrameDuration="30000" triggerSourceOrType=""
      lossyImageCompression="00">
          </NMImageModule>
          <NMIsotopeModule>
30          <EnergyWindowInformationSequence>
              <EnergyWindowRangeSequence/>
            </EnergyWindowInformationSequence>
            <RadiopharmaceuticalInformationSequence
      radiopharmacuetical="" radionuclideTotalDose="0.000000"
35    radiopharmacueticalRoute="" radiopharmacueticalVolume=""
      radiopharmacueticalStopTime="" radiopharmacueticalStartTime="">
              <CalibrationDataSequence syringeCounts=""
      energyWindowNumber="" residualSyringeCounts=""/>
            </RadiopharmaceuticalInformationSequence>
40          <RadiopharmaceuticalInformationSequence
      radiopharmacuetical="" radionuclideTotalDose="0.000000"
      radiopharmacueticalRoute="" radiopharmacueticalVolume=""
      radiopharmacueticalStopTime="" radiopharmacueticalStartTime="">
              <CalibrationDataSequence syringeCounts=""
45    energyWindowNumber="" residualSyringeCounts=""/>
            </RadiopharmaceuticalInformationSequence>
            <InterventionDrugInformationSequence
      interventionDrugDose="" interventionDrugName=""
      interventionDrugStopTime="" interventionDrugStartTime="">
50          </InterventionDrugInformationSequence>
          </NMIsotopeModule>
          <NMDetectorModule>
            <DetectorInformationSequence startAngle="0"
      zoomCenter="" zoomFactor="0.010000" focusCenterX=""
55    focusCenterY="" focalDistance="200.000000" imagePosition=""
      collimatorType="NONE" radialPosition="0.000000"
      imageOrientation="" gantryDetectorTilt=""
```

```
collimatorOrGridName="INTR" centerOfRotationOffset=""
distanceSourceToDetector="">
        <HexagonalDimension/>
        </DetectorInformationSequence>
    </NMDetectorModule>
    <NMReconstructionModule sliceLocation=""
sliceThickness="10" convolutionKernel="" spacingBetweenSlices=""
reconstructionDiameter=""/>
    <ImagePixelModule rows="256" columns="256" highBit="11"
bitsStored="12" bitsAllocated="16" samplesPerPixel="1"
pixelAspectRatio="1" pixelRepresentation="0000H"
largestImagePixelValue="" redPaletteColorLUTData=""
bluePaletteColorLUTData="" smallestImagePixelValue=""
greenPaletteColorLUTData=""
photometricInterpretation="PALETTECOLOR"
redPaletteColorLUTDescriptor="" bluePaletteColorLUTDescriptor=""
greenPaletteColorLUTDescriptor="">
        <Frame gateNumber="0" frameNumber="1"
imageViewID="View03.Det1" timePerFrame="30000"
countsPerFrame="766" detectorNumber="1" maxPixelOfFrame="2"
minPixelOfFrame="0">
```

iVBORw0KGgoAAAANSUhEUgAAAQAAAAEAEAAAAApiSv5AAAGt0lEQVR4nO3
d25bbNgyFYbl5/3fuTVczY1MWDyCwAf7fRVvamtSQQpHWgwMll1AQAAAAAAA
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAMC716bPWm+NY6wMlNFtGZQHo
tMn5U5c7uhdkCJOsBkmT3v5/P8+w/OIL0FPI49IBIBg+840xc9h35q3t+mv
jz/Ht8Y3S9STGRaabky3umms9rXtYWhvIgCHPZZNJxBdCJbkjloTJ2vH3MI3v
8x/zoRnS68tX8aTU+nfYYFIxG22sNVVtz0Ty77SkoSZTlRqqA9iW+J+9DodV0
Pq/ribsU/dqAUF312sX928miSXulPV6Ij7s1iN9k05uuOmBEmbdOuSEKcikW
nqrtedQdt04Xg/cf/Rdg014EL9u/p6PX4FK/l58n5smyAf4w91QtZylsMhE
3z425nzlFBhBIbaXRBTufn+PDrz+NVjm4fX1b0HCA7ik0mGiRismHd34S+C
KfwbvOob3m0w68JfTlmN5/sYRR8KhJZJZAkeq0q/lEk/ZX6zAMP+7NntdV0Rvz
hBfyg8S9UGxceusUhsa2+TVfKq6U+Y7CKIaTODRWyAtcPxxC/L5SLb33GLp9
0Gx01/H5aB/2uLuUztT5n/D+fzJ44bIs9jXqVF71ziigOxP9757r3fT+kh9
hPsVko3uY6ww7f3Th9YfXJJf+kGuLuF8yoRKgShzPhKeD8dfBp9Bnurcy8Z0
WH4FGDD/MhVPt1Q4G7LshGGq/70XpK2LGvNBQbvWOoti+w3/eomJsOn8+un3
9P2rROaVt3H/jooqbR7T1TFnes8SOHDiWlcawUy/F4dw55s0Mybrn6yAvmg
l+41VmFlUpBu8/u5hiLUrP3YonWrdf/f7Zm0KNrBPsw8+hm5aq7czrEauZh
362vyMAsULiMGDWGgf/3OWXe9gStNE84Qz0+aavXf5LvJCLRtqdThaFywHo
C3+ZlndL5Lk+kolyJHC8aWf/s7BZ2W5sRCWPArojTFnqP02pS750CZrHXPI
Oo5FSuxGvHo1uzHUat4zDAuvP2VhbvcEZ1pLHoZK3fAEa3oFOWK6z9vltX2
pjpb6QxXpc08u7jwIFSq8m1WjPk4KbXkmw5wxulWGYkmnm8e9N1f0XLNks+
MhmTvcahuLH0f3b8fPcV73iN5s2uF7jfT5T4CEzYvIodTcb753WTqRvZgmq
/jef5ml6rvR9yNy8y+mSZi6qu80iT7TH8OzbZUOp1Vaw1u4WttHXMWmHZVe
n5FVJ43AVo9dJ/tAvG17aBiLzfrbLDzrpmICZRrWnq0ctP2S5+F3+tnZvhs
5oXvNtL9t1GDGoPAKtiEBF9YWq+8UqS4uu6jq/92evnRUkjuVVQCD7NI1fq3
jA57o3Xi8rv6xrc1jVzF4DPuapu+R6cR+zYZZu7bRyzeMZr6Zg56Z29hhHXin
d/Ww9Y/BEdtjJBnaprIqyeTehnPevnr/LOk0bm7bp2dcuOjkrodhMHTJIOZ
hWgt7/8De3Tmblzl+jjCzhUNJI3Nj+VwvPgQkJhlFciGrJUYYlnexyaRdp2p
aKzW/YXg6gMFSe2pd3zx4x4KZ+zTvKP7S7FSLm8KUS8as38KPfPPbbvHzCVJpK
1f5UwQ6o2i4HpK5XT6a2ZXP9HZXmE4TPUUuvE/jWuBy3OhliRFFozJ27ZIRn
z8nR/OvQKQ6l6T3kql5lBrj12H7F3EcNZYPKu1pqJTp3DyL74yaG65iE4yFI
bIAWKGRvx0MoPj8kwCJaDLLKcj75ZRzdnzpn+njBfEW7GLKTIdL0V3ettfN
9z+WaUrVQOJoEA5NOrZD0AU2xs9Kbpl/OhD/dKmO1F9Hn2qBXUeJe4IpTOPc
otA1gZlQaP6zkQVc65VNVtvuoRfRLyOFD3uaIp4gXWuJKzXnJS1V3tpVhP5
ng912Ry3yGtnr8PP38PHDZ3Y5TAnlGnRdl+8qqfvP1cxtp5nGZy3u0Hgk/m
ruISxNObSMkUfepKye1FVfUCerW1gr2rhfMeShVgVzjig38JpD8L3VSnBV/
y064NVZAu9ZhmO/r71qzcBbqNmqpoq1ufsfSjNlo8G2AnjkWJ//TasMNHXH
```

toP3Xm6hn8L+aeyfn9P756228KkFijx6SZbTGVad4HmZwZuz0ll/8coS5XC
/x+b3atv3eGK8bxKRzvxT9a77gOc97bu3OVb09LMNhsEP3u///ReC0N3Xdd
mdiElnQud12nktXtAuCa+ibssMeS0xsTia3T5ghu6Akb+PmQwqAAAAAAAA
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAE7+BWA6AwG7AX2YAAAAAE1F
TkSuQmCC</Frame>
        <Frame gateNumber="0" frameNumber="2"
imageViewID="View04.Det2" timePerFrame="30000"
countsPerFrame="0" detectorNumber="2" maxPixelOfFrame="0"
minPixelOfFrame="0">
iVBORw0KGgoAAAANSUhEUgAAAQAAAAEAEAAAAApiSv5AAAAlUlEQVR4nO3
BAQEAAACAkP6v7ggKAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAAAAAAAgKoBAR4AAZF/oKMAAAAASUVORK5CYII=</Frame>
        </ImagePixelModule>
      </ImageIE>
    </NMImageIOD>
</ADACImage>

## Appendix 2 - <ADACImage.dtd>

```
<!--
file  :    ADACImage.dtd
purpose:    This is the DTD used to generate the XML image from the Binner
created:    26-Oct-00
property of: ADAC Laboratories

revision history:
    26-Oct-00  CM      initial version
    21-Nov-00  CM       i)  Changed MultiframeModule to MultiFrameModule
                        ii) The pixelData is moved in to the Element.
                        iii) The order of the elements are changed so that
                             all the encoded data will appear at the very end
                             of the XML image
    04-Jan-01  CM      i)  Removed the Variable Frame Element
                       ii) Added the gateNumber in Frame Element
                       iii) Added the detectorNumber in Frame Element
    25-Jan-01  CM      i)  Changes which will make the DTD less restrictive to
                           generate XML ouput and validation are made. These
                           include changing mandatory Elements to optional etc.
                       ii) ID's were replaced by CDATA
    15-Feb-01  CM      Added the Element ADACCorrectionsIE and related elements
    16-Feb-01  CM      Added the Element NameAndValue to hold data from control server
    04-Mar-01  CM      Following the fixes in the xmllolib the ADACCorrectionsIE and
                          other elements were changed as optional from required.
    30-Mar-01  CM      Added imageOrientation,patientRoll and adacPatientPosition
-->
<!ELEMENT ADACImage (ADACPrivateIOD, NMImageIOD)>
<!ELEMENT ADACPrivateIOD (ADACAcquisitionIE, ADACEquipmentIE,
ADACReconstructionAndProcessingIE, ADACMiscIE, ADACCorrectionsIE)>
<!ELEMENT NMImageIOD (PatientIE, StudyIE, SeriesIE, FrameOfReferenceIE?, EquipmentIE,
GeneralIE?, ImageIE)>
<!ELEMENT ADACAcquisitionIE (StaticAcquisitionModule?, DynamicAcquisitionModule?,
GatedAcquisitionModule?, MCDAcquisitionModule?, TotalBodyAcquisitionModule?,
VANTAGEAcquisitionModule?)>
<!ATTLIST ADACAcquisitionIE
  isotopeImagingMode CDATA #IMPLIED
  uniformityCorrection CDATA #IMPLIED
  totalAcquisitionTime CDATA #IMPLIED
  objectDataType CDATA #IMPLIED
  uniquePatientKey CDATA #IMPLIED
  uniqueObjectKey CDATA #IMPLIED
  corCorrectionFlag CDATA #IMPLIED
  numberOfXYSets CDATA #IMPLIED
  scaleFactorOfSets CDATA #IMPLIED
>
<!ELEMENT ADACEquipmentIE (ADACDetectorModule)>
<!ATTLIST ADACEquipmentIE
  clientName CDATA #IMPLIED
>
<!ELEMENT ADACReconstructionAndProcessingIE (FilterModule, ROIModule, ReorientationModule,
ColorModule)>
<!ATTLIST ADACReconstructionAndProcessingIE
  associatedParentFile CDATA #IMPLIED
  associatedHistogramCurveFile CDATA #IMPLIED
  associatedNormalCurveFile CDATA #IMPLIED
  associatedPathAndFileName CDATA #IMPLIED
  reconstructionType CDATA #IMPLIED
  limitedReconstructionStartSlice CDATA #IMPLIED
```

```
              manipulatedImage CDATA #IMPLIED
              curveOrROISetName CDATA #IMPLIED
              specificCurveName CDATA #IMPLIED
              xDimensionOfAssciatedImage CDATA #IMPLIED
    5         yDimensionOfAssciatedImage CDATA #IMPLIED
              approximateEjectionFraction CDATA #IMPLIED
              imageViewID CDATA #REQUIRED
            >
            <!ELEMENT ADACMiscIE (NameAndValue*)>
   10       <!ATTLIST ADACMiscIE
              sizeOfSubHeaders CDATA #IMPLIED
              dirEntries CDATA #IMPLIED
              minTimeValue CDATA #IMPLIED
              maxTimeValue CDATA #IMPLIED
   15         rateDifference CDATA #IMPLIED
              dataStructureArray CDATA #IMPLIED
              vfrStructure CDATA #IMPLIED
              horizontalFOVOffsetInMM CDATA #IMPLIED
              verticalFOVOffsetInMM CDATA #IMPLIED
   20         unUsed1 CDATA #IMPLIED
              unUsed2 CDATA #IMPLIED
              unUsed3 CDATA #IMPLIED
              unUsed4 CDATA #IMPLIED
              binningAlgoVersion CDATA #IMPLIED
   25         programSpecifiResult CDATA #IMPLIED
              imageOrientation CDATA #IMPLIED
              patientRoll CDATA #IMPLIED
              adacPatientPosition CDATA #IMPLIED
            >
   30       <!ELEMENT ADACCorrectionsIE (CORCorrectionModule, ImageOffsetCorrectionModule)>
            <!ELEMENT PatientIE (PatientModule)>
            <!ELEMENT StudyIE (GeneralStudyModule, PatientStudyModule?)>
            <!ELEMENT SeriesIE (GeneralSeriesModule, NMPETPatientOrientationModule?)>
            <!ELEMENT FrameOfReferenceIE (FrameOfReferenceModule)>
   35       <!ELEMENT EquipmentIE (GeneralEquipmentModule)>
            <!ELEMENT GeneralIE (VOI_LUTModule?, SOPCommonModule?)>
            <!ELEMENT ImageIE (GeneralImageModule, NMImagePixelModule, MultiFrameModule,
            NMMultiFrameModule, NMImageModule, NMIsotopeModule, NMDetectorModule,
            NMTomoAcquisitionModule?, NMMultiGatedAcquisitionModule?, NMPhaseModule?,
   40       NMReconstructionModule?, OverlayPlaneModule?, MultiframeOverlayModule?, CurveModule?,
            ImagePixelModule)>
            <!ELEMENT PatientModule (ReferencedPatientSequence?, OtherPatientID*, OtherPatientName*)>
            <!ATTLIST PatientModule
              patientsName CDATA #REQUIRED
   45         patientsID CDATA #REQUIRED
              patientsBirthDate CDATA #REQUIRED
              patientsSex (M | F | O) #REQUIRED
              patientsBirthTime CDATA #IMPLIED
              ethnicGroup CDATA #IMPLIED
   50         patientComments CDATA #IMPLIED
            >
            <!ELEMENT GeneralStudyModule (PhysicianOfRecord*, NameOfPhysicianReadingStudy*,
            ReferencedStudySequence*, ProcedureCodeSequence+)>
            <!ATTLIST GeneralStudyModule
   55         studyInstanceID CDATA #REQUIRED
              studyDate CDATA #REQUIRED
              studyTime CDATA #REQUIRED
              referringPhysiciansName CDATA #REQUIRED
              studyID CDATA #REQUIRED
   60         accessionNumber CDATA #REQUIRED
              studyDescription CDATA #IMPLIED
            >
```

```
     <!ELEMENT PatientStudyModule EMPTY>
     <!ATTLIST PatientStudyModule
       admittingDiagnosesDescription CDATA #IMPLIED
       patientsAge CDATA #IMPLIED
5      patientsSize CDATA #IMPLIED
       patientsWeight CDATA #IMPLIED
       occupation CDATA #IMPLIED
       additionalPatientsHistory CDATA #IMPLIED
     >
10   <!ELEMENT GeneralSeriesModule (ReferencedStudyComponentSequence?,
     RequestAttributeSequence*, PerformedActionItemSequence*)>
     <!ATTLIST GeneralSeriesModule
       modality (CR | MR | US | BI | DD | ES | MA | PT | ST | XA | RTIMAGE | RTSTRUCT | RTRECORD |
       DX | IO | GM | XC | CT | NM | OT | CD | DG | LS | MS | RG | TG | RF | RTDOSE | RTPLAN | HC | MG |
15     PX | SM) #REQUIRED
       seriesInstanceUID CDATA #REQUIRED
       seriesNumber CDATA #REQUIRED
       laterality (R | L) #IMPLIED
       seriesDate CDATA #IMPLIED
20     seriesTime CDATA #IMPLIED
       performingPhysiciansName CDATA #IMPLIED
       protocolName CDATA #IMPLIED
       seriesDescription CDATA #IMPLIED
       operatorsName CDATA #IMPLIED
25     bodyPartExamined (SKULL | CSPINE | TSPINE | LSPINE | SSPINE | COCCYX | CHEST | CLAVICLE
       | BREAST | ABDOMEN | PELVIS | HIP | SHOULDER | ELBOW | KNEE | ANKLE | HAND | FOOT |
       EXTREMITY | HEAD | HEART | NECK | LEG | ARM | JAW) #IMPLIED
         patientPosition (HFP | HFDR | FFDR | FFP | HFS | HFDL | FFDL | FFS | OTHER) #IMPLIED
         smallestPixelValueInSeries CDATA #IMPLIED
30     largestPixelValueInSeries CDATA #IMPLIED
       performedProcedureStepID CDATA #IMPLIED
       performedProcedureStepStartDate CDATA #IMPLIED
       performedProcedureStepStartTime CDATA #IMPLIED
       performedProcedureStepDescription CDATA #IMPLIED
35   >
```

Appendix 3 - <protocol.xml>

```
<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE protocols SYSTEM "protocol.dtd">
<protocols>
  <!-- protocol record # 0 -->
  <protocol>
    <protoinfo>
      <protoname type="TRAIT_PROT_NAME">MIBI MIBI</protoname>
      <tval type="TRAIT_PROT_ANATOMICAL">Cardiac</tval>
    </protoinfo>
    <protosteps>
      <protostep>
        <acquisitionstep>
          <acqstepinfo>
            <tval type="TRAIT_ACQR_SCRIPT_NAME">ect</tval>
          </acqstepinfo>
          <acqstepaction>
            <concurrent>
              <tval type="TRAIT_ACQR_NAME">Rest MIBI</tval>
              <tval
type="TRAIT_ACQR_APPDATA_CLASSNAME">data.SPECTAcqStep</tval>
              <tval type="TRAIT_ACQR_X_DIMENSION">64</tval>
              <tval type="TRAIT_ACQR_Y_DIMENSION">64</tval>
              <tval type="TRAIT_ACQR_ROTATION_CLOCKWISE">true</tval>
              <tval type="TRAIT_ACQR_TOTAL_ROTATION">180</tval>
              <tval type="TRAIT_ACQR_START_ANGLE">0</tval>
              <tval type="TRAIT_ACQR_RELATIVE_ANGLE">90</tval>
              <tval type="TRAIT_ACQR_DEPTH">16</tval>
              <tval type="TRAIT_ACQR_MAX_PIXEL">65535</tval>
              <tval type="TRAIT_ACQR_ZOOM">1</tval>
              <tval type="TRAIT_ACQR_DETECTORS">12</tval>
              <tval type="TRAIT_ACQR_FLOOD_TABLE">INTR.FCR</tval>
              <tval type="TRAIT_ACQR_MILLISECONDS">10000</tval>
              <tval type="TRAIT_ACQR_KCOUNTS">0</tval>
              <tval type="TRAIT_ACQR_IS_GATED">false</tval>
              <tval type="TRAIT_ACQR_STOP_ON_SATURATE">false</tval>
              <tval type="TRAIT_ACQR_IS_COINCIDENT">false</tval>
              <tval type="TRAIT_ACQR_FRAMES_PER_AZIMUTH">1</tval>
              <tval type="TRAIT_ACQR_NUM_AZIMUTHS">32</tval>
              <tval type="TRAIT_ACQR_COMBINE_HEADS">true</tval>
              <tval type="TRAIT_ACQR_IS_ECT_CONTINUOUS">false</tval>
              <tval type="TRAIT_ACQR_DOSAGE_ADMIN_TIME">00:00:00</tval>
              <tval type="TRAIT_ACQR_IS_ECT_NONCIRCULAR">true</tval>
            </concurrent>
          </acqstepaction>
        </acquisitionstep>
      </protostep>
      <protostep>
        <acquisitionstep>
          <acqstepinfo>
            <tval type="TRAIT_ACQR_SCRIPT_NAME">ect</tval>
          </acqstepinfo>
          <acqstepaction>
            <concurrent>
              <tval type="TRAIT_ACQR_NAME">Stress MIBI</tval>
              <tval
type="TRAIT_ACQR_APPDATA_CLASSNAME">data.SPECTAcqStep</tval>
              <tval type="TRAIT_ACQR_X_DIMENSION">64</tval>
              <tval type="TRAIT_ACQR_Y_DIMENSION">64</tval>
              <tval type="TRAIT_ACQR_ROTATION_CLOCKWISE">true</tval>
```

```
                    <tval type="TRAIT_ACQR_TOTAL_ROTATION">180</tval>
                    <tval type="TRAIT_ACQR_START_ANGLE">0</tval>
                    <tval type="TRAIT_ACQR_RELATIVE_ANGLE">90</tval>
                    <tval type="TRAIT_ACQR_DEPTH">16</tval>
  5                 <tval type="TRAIT_ACQR_MAX_PIXEL">65535</tval>
                    <tval type="TRAIT_ACQR_ZOOM">1</tval>
                    <tval type="TRAIT_ACQR_DETECTORS">12</tval>
                    <tval type="TRAIT_ACQR_FLOOD_TABLE">INTR.FCR</tval>
                    <tval type="TRAIT_ACQR_MILLISECONDS">10000</tval>
 10                 <tval type="TRAIT_ACQR_KCOUNTS">0</tval>
                    <tval type="TRAIT_ACQR_IS_GATED">false</tval>
                    <tval type="TRAIT_ACQR_STOP_ON_SATURATE">false</tval>
                    <tval type="TRAIT_ACQR_IS_COINCIDENT">false</tval>
                    <tval type="TRAIT_ACQR_FRAMES_PER_AZIMUTH">1</tval>
 15                 <tval type="TRAIT_ACQR_NUM_AZIMUTHS">32</tval>
                    <tval type="TRAIT_ACQR_COMBINE_HEADS">true</tval>
                    <tval type="TRAIT_ACQR_IS_ECT_CONTINUOUS">false</tval>
                    <tval type="TRAIT_ACQR_DOSAGE_ADMIN_TIME">00:00:00</tval>
                    <tval type="TRAIT_ACQR_IS_ECT_NONCIRCULAR">true</tval>
 20               </concurrent>
                </acqstepaction>
              </acquisitionstep>
            </protostep>
          </protosteps>
 25     </protocol>
        <!-- protocol record # 1 -->
        <protocol>
          <protoinfo>
            <protoname type="TRAIT_PROT_NAME">Dual Isotope</protoname>
 30         <tval type="TRAIT_PROT_ANATOMICAL">Cardiac</tval>
          </protoinfo>
          <protosteps>
            <protostep>
              <acquisitionstep>
 35             <acqstepinfo>
                  <tval type="TRAIT_ACQR_SCRIPT_NAME">ect</tval>
                </acqstepinfo>
                <acqstepaction>
                  <concurrent>
 40                 <tval type="TRAIT_ACQR_NAME">ect</tval>
                    <tval
```

Appendix 4 - tbbase.asl

```
      #
      # file: tbbase.asl
  5   # purpose: PreProgram Script for 'basic' TotalBody(tb) study.
      #
      # created: 3-Jan-01
      # property of ADAC Laboratories
      #
 10   # revision history:
      #        3-Jan-00        DC      initial version
      #
      # script dependencies:
      #        - Exchanger is parked (check ColPark)
 15   #        - User Override is Off
      #        - Rings are locked at 180.
      #
      # target values (Input):
      #        none
 20   #
      # return values (Output):
      #        false - Script failed to complete
      #        true - Script completed
      #
 25   # $Header: /usr/adac/Repository/camera/camera/control/etc/easl.scripts/tbbase.asl,v 1.18
      2001/05/08 05:58:15 sheavner Exp $
      #
      script "tbbase"

 30          # Debug message - let me know the script has started ok
             choiceNum = message( "DEBUG MESSAGE -- Starting tbbase.asl - Gantry will move
      to scan setup position when you click ok")
                            choices "DEBUG OK!";

 35          # Discuss study with tech, subtract off one FOV
             if ( TRAIT_ACQR_SCAN_LENGTH > 0 ) {
                     TRAIT_ACQR_SCAN_LENGTH = TRAIT_ACQR_SCAN_LENGTH -
      TRAIT_ACQR_FOV_SIZE_Y;
                     } else {
 40                     TRAIT_ACQR_SCAN_LENGTH = TRAIT_ACQR_SCAN_LENGTH +
      TRAIT_ACQR_FOV_SIZE_Y;
                     }

             TABLE_EXTEND_POSITION_VELOCITY = 40.0;
 45
             #
             # Set the starting and ending(target) position of the longitudinal
             # motion and calculate the scan length, in microns for the binner.
             #
 50
             _startTablePos = TRAIT_ACQR_TRANSLATE_POS;
             _endTablePos = TRAIT_ACQR_TRANSLATE_POS +
      TRAIT_ACQR_SCAN_LENGTH;

 55          _tb_lower_limit = GantryTB lower limit;
```

```
          _tb_upper_limit = GantryTB upper limit;
          if ( (_startTablePos > _tb_upper_limit) or (_startTablePos < _tb_lower_limit) ) {
                  choiceNum = message("EASL_STUDY_TB_START_POS",
_tb_lower_limit/10, _tb_upper_limit/10, (_tb_upper_limit-
_tb_lower_limit+TRAIT_ACQR_FOV_SIZE_Y)/10 ) choices "EASL_CONTINUE";
                  return;
          }
          if ( (_endTablePos > _tb_upper_limit) or (_endTablePos < _tb_lower_limit) ) {
                  if (TRAIT_ACQR_SCAN_LENGTH > 0) {
                          _allowable_length = _tb_upper_limit-
_startTablePos+TRAIT_ACQR_FOV_SIZE_Y;
                  } else {
                          _allowable_length = _tb_lower_limit-
_startTablePos+TRAIT_ACQR_FOV_SIZE_Y;
                  }
                  choiceNum = message("EASL_STUDY_TB_END_POS",
_tb_lower_limit/10, _tb_upper_limit/10, _allowable_length/10, _startTablePos/10 ) choices
"EASL_CONTINUE";
                  return;
          }


          #
          # Negative scan length implies that we are scanning from foot to head
          #

          show status " ************(script)          Starting position is " + _startTablePos + "
mm";
          show status " ************(script)          Ending(target) position is " +
_endTablePos + " mm";
          show status " ************(script)          The required scan length is " +
TRAIT_ACQR_SCAN_LENGTH + " mm";

          # Leftover -- remove when can verify it's ok
          StudyVGAngle = 180;  start StudyVGAngle;

          # calculate the longitudinal velocity
          # ( negative indicates that we are moving from foot to head,
          #        the start position is greater than the stop position )

          #_scanSpeed is mm per second
          _scanSpeed = TRAIT_ACQR_TBODY_SPEED;

          # test the speed for a valid range

          show status " ************(script)          Scan Speed is " + _scanSpeed + "
mm/sec";

          # ------------------------------------------------------------------------
          #
          show status "%%%%%%%%%%%%(script)          Running TB setup script
%%%%%%%%%%%%";
          _finishedSetup = false;
          while (_finishedSetup = false)
          {
                  StudyTBSetup = _startTablePos;
                  run StudyTBSetup;
```

```
                    if (StudyTBSetup != true)
                    {
                            if (StudyTBSetup < 0)
                                    return;
                            choicenum = message("EASL_STUDY_SETUP_FAILED") choices
        "EASL_RETRY", "EASL_CANCEL";
                            if (choicenum = 2)
                                    return;
                    }
                    else
                    {
                            _finishedSetup = true;
                    }
            }


        # ------------------------------------------------------------------
        #

            # Start binner and wait for the start button
            show status " %%%%%%%%%%%%%%%(script)         WAITING FOR START
        %%%%%%%%%%%%%";

            choiceNum = message( "DEBUG MESSAGE -- Gantry is in position, Click start to
        begin study (after clicking ok)" )
                            choices "OK";
            # status message( "Press the START button to begin");

            enable imaging;
            wait until user requests imaging start;

            show status " %%%%%%%%%%%%%%%(script)         User has pressed START
        %%%%%%%%%%%%%";

        # ------------------------------------------------------------------
        #
            #
            # For Total Body acquisitions there are 3 stages
            #
            # 1. The mask is opened one row at a time and when fully open the binning halts
        waiting for the table to start moving
            # 2. The table moves the required distance at the required speed with the mask fully
        open and binning in progress
            # 3. The table stops moving and the mask automatically starts to close.
            #

            #
            # Setup the target position for the acquisition and the speed for the table motion during
        the acquisition
            #
            StudyTB = _endTablePos;
            StudyTB velocity = _scanSpeed;

            # Start StudyMonitor to watch for gantry exceptions, start after setup.ppm completes
            start StudyMonitor;
```

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```
#
# send the start imaging tag into the data stream and so to the
# binner to start the imaging
#
start imaging;

show status " %%%%%%%%%%%%%%(script)          Imaging has started, waiting for
the mask to be fully open %%%%%%%%%%%";


# Wait for the mask to be fully open. This is indtcated by the binner state changing
from
# Inprogress to ReadyToMove


#
# check that the imaging did start
#
_loop = 90;
while (imaging is not underway)
{
        if ( _loop < 0 )
        {
                show status " %%%%%%%%%%%%%%(script) Imaging did not start
after 90 seconds";
                choiceNum = message( "DEBUG MESSAGE -- Imaging did not
start after 90 seconds." )
                choices "Abort";
                stop StudyMonitor;
                current setting = false;
                return;
        }
        _loop = _loop - 1;
        pause 1.0;
}

        show status " %%%%%%%%%%%%%%(script)          Imaging has started, waiting for
the mask to be fully open %%%%%%%%%%%";

# Wait for the mask to be fully open. This is indicated by the binner
# state changing from Inprogress to ReadyToMove

_quiet = 0;
while (imaging is not ready for motion)
{
        if ( StudyMonitor is not working)
        {
                show status "%%%%%%%%%%%%%%(script)          Study Monitor
is not working - waiting for mask to open %%%%%%%%%%%";
                stop imaging;
                stop StudyMonitor;
                return;
        }

        if ( imaging is complete )
        {
```

```
                              show status "%%%%%%%%%%%%(script)          IMAGING IS
COMPLETE - STOPPING 1%%%%%%%%%%%";
                              stop StudyMonitor;
                              return;
          }


          _quiet = _quiet + 1;
          if (_quiet > 50)
          {
                              show status " %%%%%%%%%%%%%(script)          Still waiting
for mask to be fully open %%%%%%%%%%%";
                              _quiet = 0;
          }
          pause 0.2;
          }


          show status " %%%%%%%%%%%%%%(script)          Total body mask is fully open,
requesting the start of table motion %%%%%%%%%%%";

          start StudyTB;

          _quiet = 0;
          while (imaging is not complete)
          {
                    if ( StudyMonitor is not working)
                    {
                              show status "%%%%%%%%%%%%%%(script)          Study Monitor
is not working - moving gantry %%%%%%%%%%%";
                              stop imaging;
                              stop StudyMonitor;
                              return;
                    }

                    if ( StudyTB is working )
                    {
                              if ( _quiet > 50 )
                              {
                                        show status " %%%%%%%%%%%%%%(script)
Moving gantry, scanning in progress %%%%%%%%%%%";
                                        _quiet = 0;
                              }
                    }
                    else
                    {
                              if ( _quiet > 50 )
                              {
                                        show status " %%%%%%%%%%%%%%(script)
Gantry not moving, final curtaining in progress %%%%%%%%%%%";
                                        _quiet = 0;
                              }
                              if ( StudyTB != 1)
                              {
                                        show warning "Study aborted by user while table was
moving";

                                        stop StudyMonitor;
```

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```
                        return;
                }
        }
        _quiet = _quiet + 1;
        pause 0.2;
    }

    if ( StudyTB is working )
    {
        # Something is wrong, table should have stopped.
        show status "%%%%%%%%%%%%(script)        Why didn't the table
stop!    Error!!!  %%%%%%%%%%%";
        choicenum = message( "Longitudinal motion should have stopped, Study
Aborted.") choices " OK  ";
        stop StudyTB;
        stop StudyMonitor;
        return;
    }

    if ( StudyTB != 1)
    {
        show warning "Study aborted by user while table was moving";
        stop StudyMonitor;
        return;
    }

    stop StudyMonitor;
    current setting = true;
    show status "%%%%%%%%%%%%(script)        Imaging completed -- Script
tbbase.asl done";
    return;


#       End of the the script
```